Qld Branch ANZRS Meeting

Robert Carroll

Respiratory Advanced Trainee

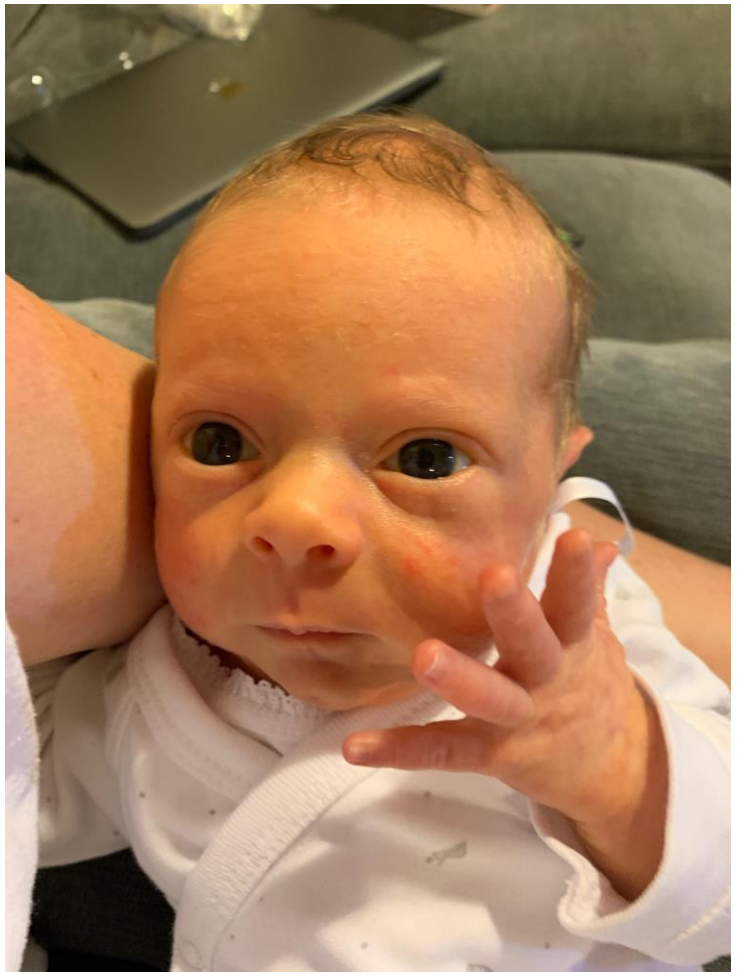
Logan Hospital

Acknowledgements

- Sharna Wilkinson & Logan Respiratory Lab
- Dr Khoa Tran

Excuses

- Apologies for the no title
- However



Outline

- Case 1
  - What contraindications?
  - Discussion
- Case 2
  - Oh that’s why we do the KCO
  - Discussion
- Questions

Case 1 – what contraindications?

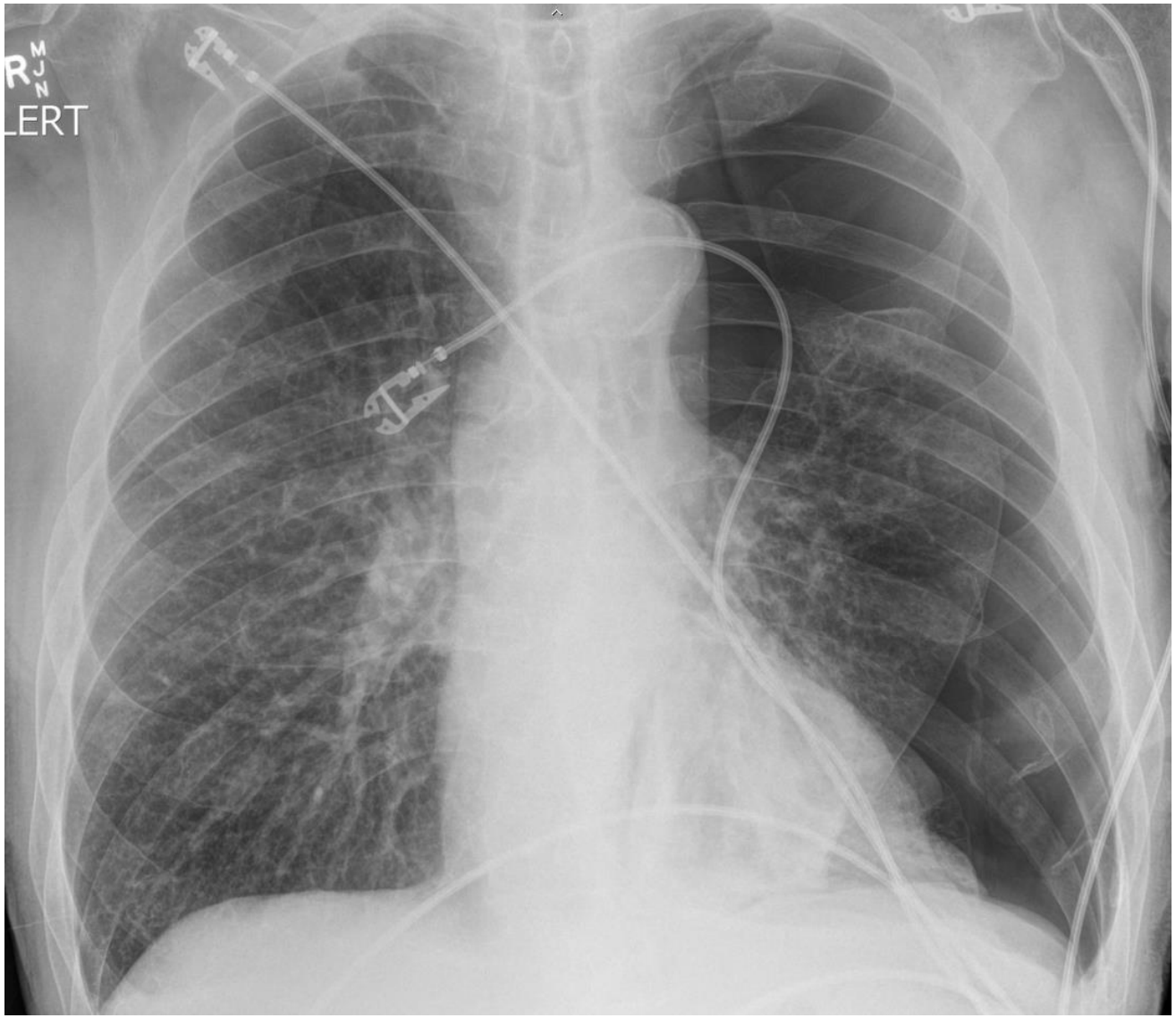
Lab presentation

- 82M
- Referred for complex lung function by respiratory team
- Question?
  - Satisfactory lung function to tolerate potential thoracic surgery
  - Wedge vs lobectomy vs other
  - Patient currently has a pneumothorax + ICC…

Background

- Admitted to hospital with shortness of breath
- Increasing after four days
- Associated chest pain
- Stairs at home more challenging

- HTN
- Heavy ex smoker
  - 80 pack years
  - No formal COPD Dx
  - Not on inhalers prior to admission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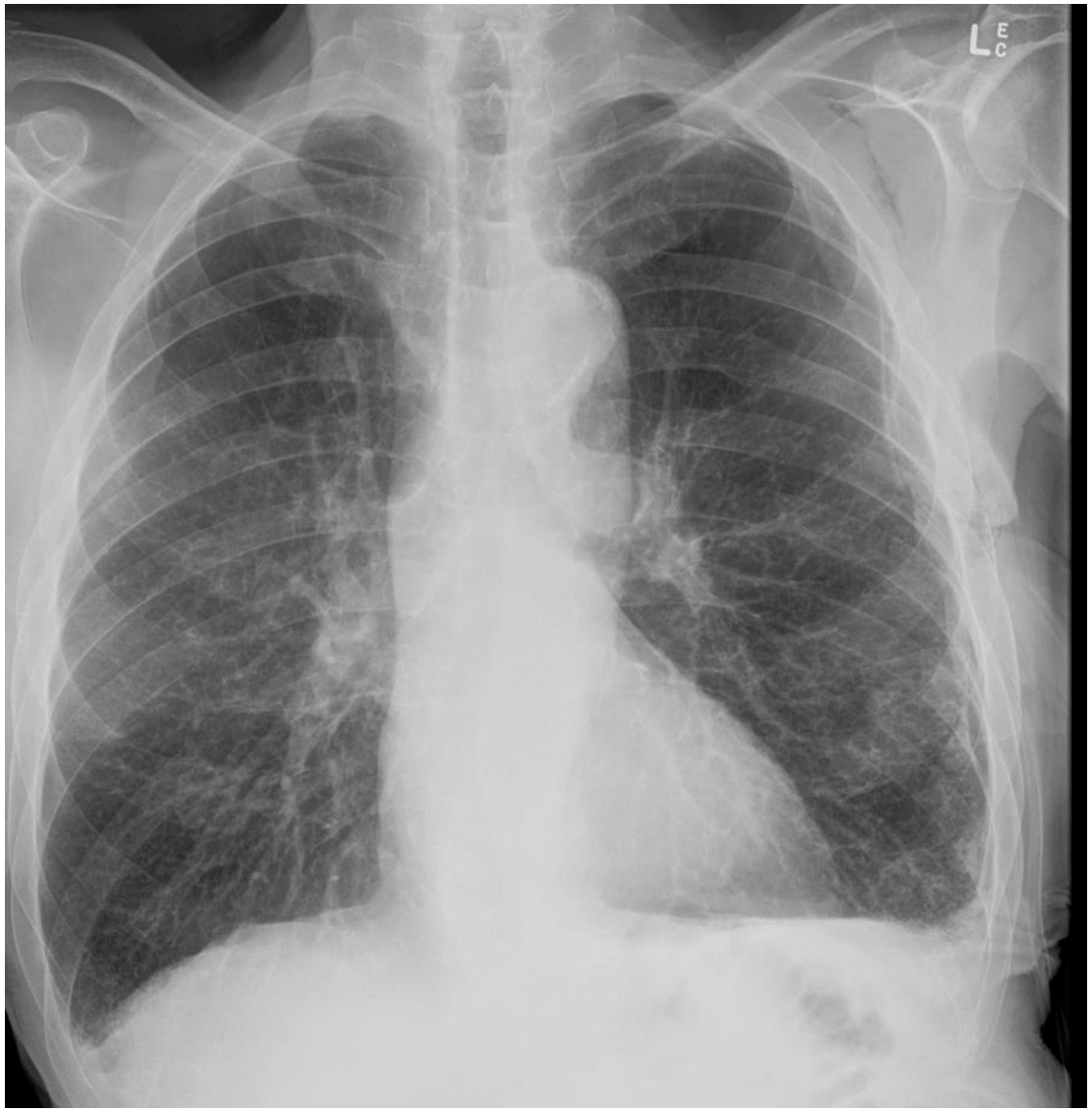
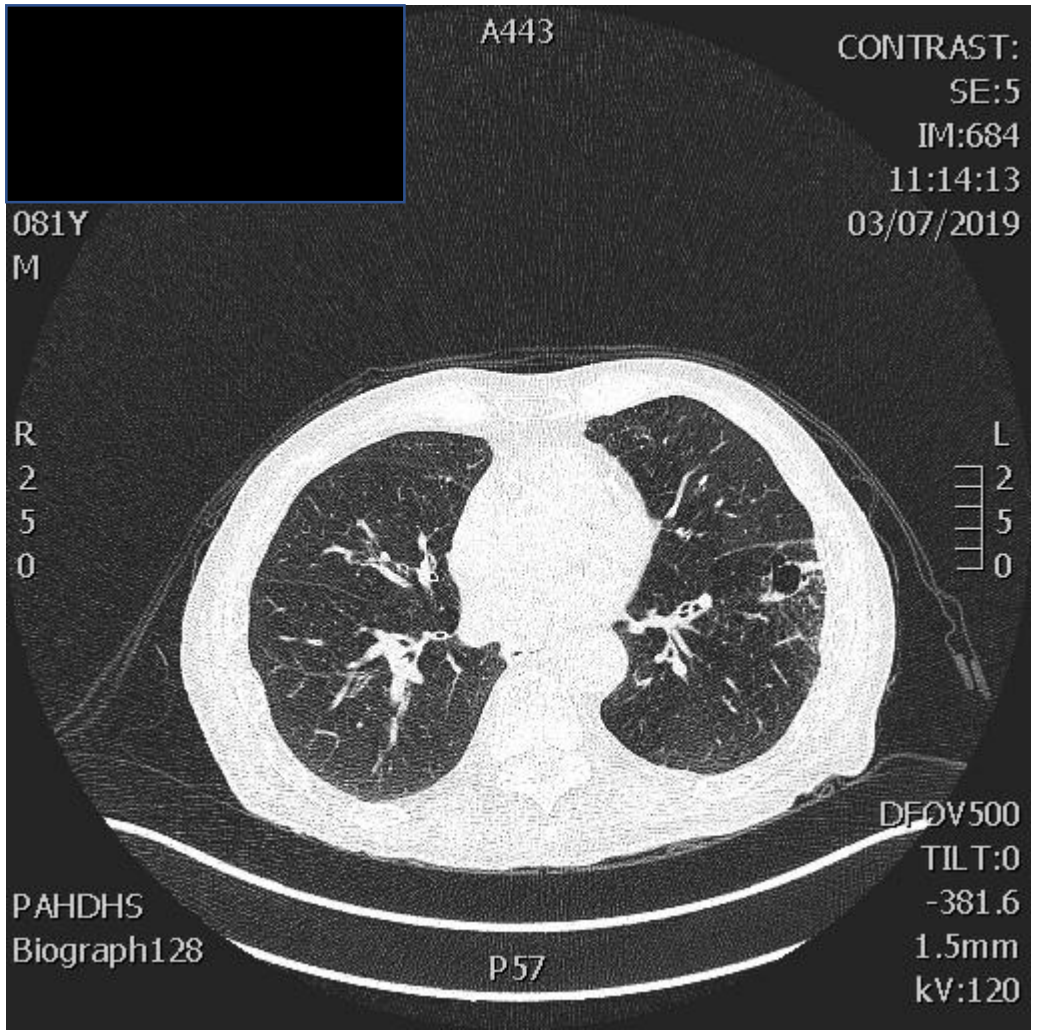


Progress

- Day 14
- Persistent airleak
- Concerning CT with cystic lesion felt to represent cystic adenocarcinoma
- PET scan

CT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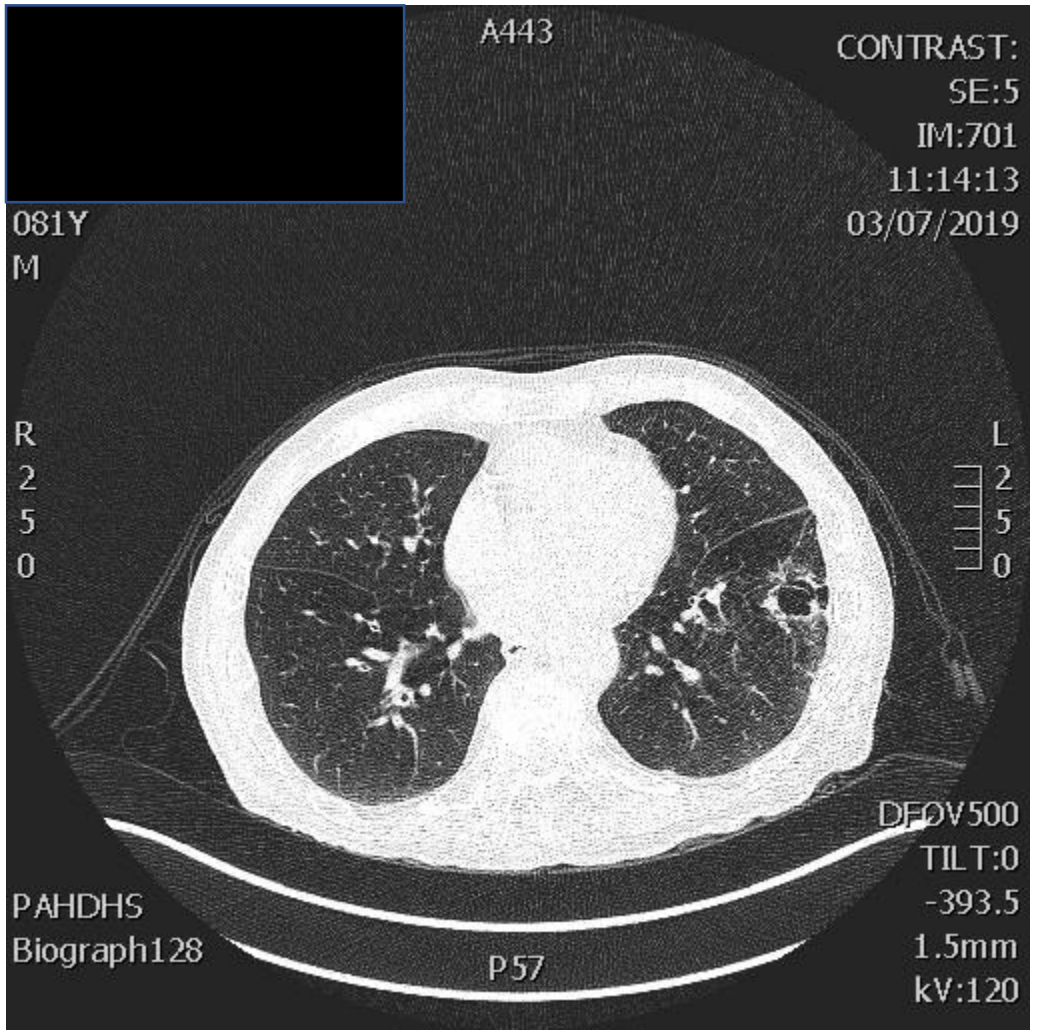
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PET


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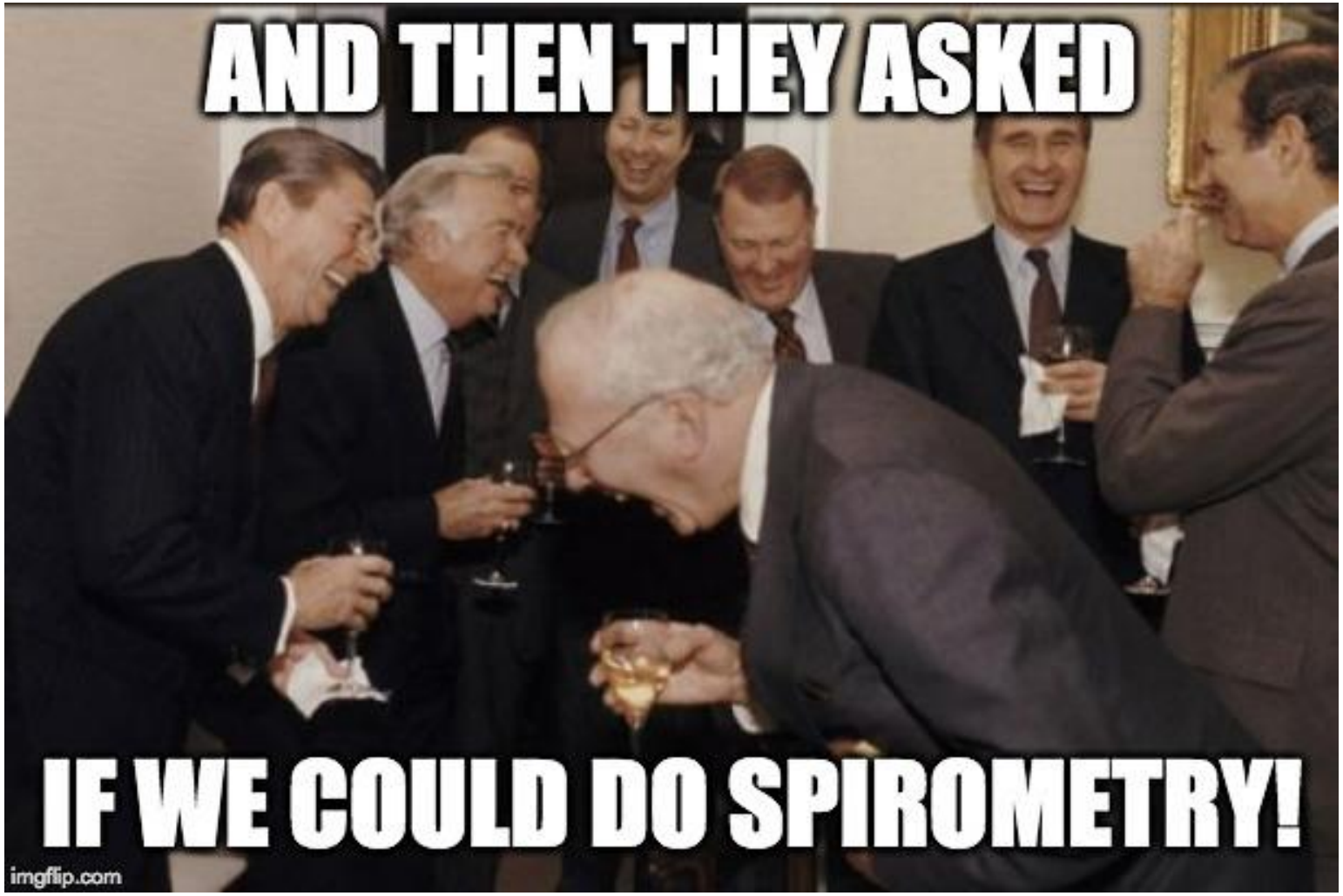
Opinions

- Radiology opinion ?biopsy →

- Surgical opinion →
  - Get lung function

RFTs

Lab opinion




MasterScreen Body
JAEGER

Caveats

- Measured the volume of the ICC chamber
- Attempted He dilution and body plethysmography
  - Abandoned He dilution due to patient fatigue
- Medical supervision at all times
- Drain unclamped in between trials
- Drain clamped during trials
- Body pleth 2 trials
  - Clamped vs unclamped
  - Assess the size of the ‘leak’

Physiology

- FVC
  - Peak Pinsp -47cmH20
    - FRC to TLC
  - Peak Pexp +102cmH20
    - TLC to RV
- Pleural space
  - Usually negative pressure during normal respiration
  - Sum of all partial pressures of gases in the capillary blood is 760mmHg
  - Pleural pressure would need to -36cmH20 to extract gas from the blood
  - Note Pinsp during FVC

Tiller et al. Effect of spirometry on intra-thoracic pressures. BMC Res Notes 2018; 11:110

Noppen M. Spontaneous pneumothorax: epidemiology, pathophysiology and cause. Eur Respir Rev 2010; 19:117, 217-19

Anticipated physiology

- Spirometry
  - FEV1 – decreased
  - FVC – decreased
  - Probably FEV1 fall > FVC
  - Mainly due to ‘leak’
- Gas transfer
  - DLCO – probably no difference
- Volumes
  - Body box - decreased

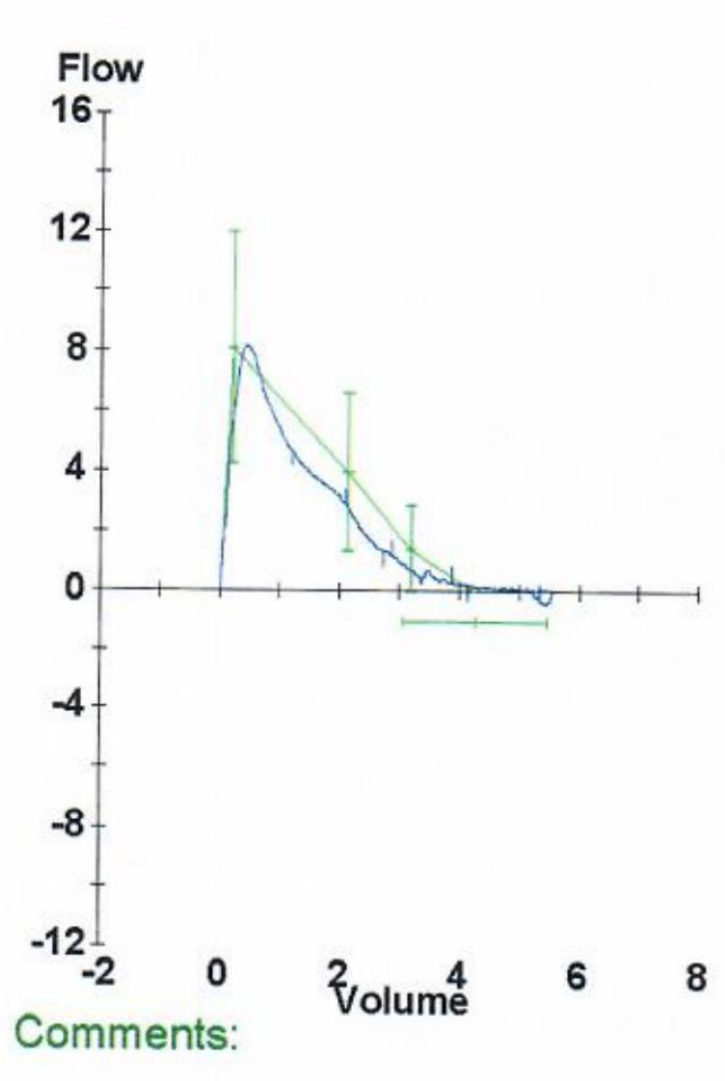
What happened

- Well, not much
- It turned out that his air leak stopped overnight
- No bubble or swing in the ICC chamber
  - Under water seal mechanism
- Spirometry was limited a bit by pain
- No change in TLC between clamped and unclamped tests
  - Confirmation that air leak ceased
  - ?new test for ‘cure’ of pneumothorax

Results

Age: 70 Height(cm): 176 Weight(kg): 75.0 Body Mass Index: 24.21 Gender: Male

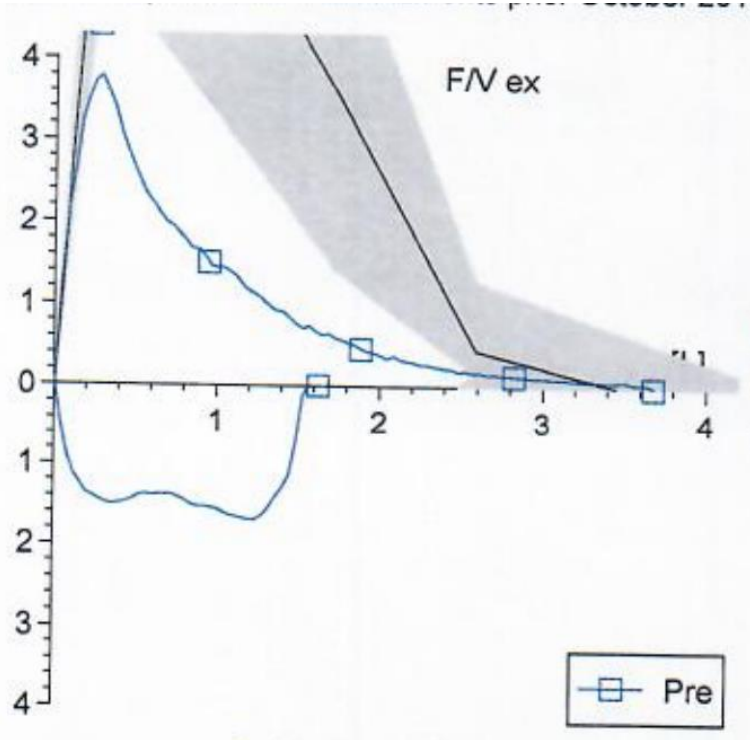
		Ref	Ref +/- C.I.	Pre	% Ref	Post	% Ref	%Chg
Spirometry								
FVC	Liters	4.27	(3.0 - 5.5)	(5.55)	(130)			
FEV1	Liters	2.88	(2.0 - 3.8)	2.91	101			
FEV1/FVC	%	69	(55.7 - 81.4)	(52)				
FEF25-75%	L/sec	2.62	(0.8 - 4.5)	(0.68)	(26)			
PEF	L/sec	8.10	(4.2 - 12.0)	8.23	102			
Lung Volumes								
TLC	Liters	6.34	(5.3 - 7.3)	(7.56)	(119)			
VC	Liters	4.27	(2.9 - 5.6)	(5.76)	(135)			
IC	Liters	2.91	(2.2 - 3.6)	2.75	94			
FRC PL	Liters	3.74	(2.5 - 5.0)	4.81	128			
RV	Liters	2.49	(1.7 - 3.3)	1.80	72			
RV/TLC	%	41	(28.7 - 52.7)	(24)				
Diffusing Capacity	Note: DLCO assumes a normal Haemoglobin of 13.4 g/dL for females and 14.6 g/dL for males.							
DLCO	mL/mmHg/min	19.7	(11.4 - 28.0)	14.6	74			
DL Adj	mL/mmHg/min	19.7	(11.4 - 28.0)	14.6	74			
DLCO/VA	mL/mHg/min/L	3.64	(1.8 - 5.5)	2.22	61			
DL/VA Adj	mL/mHg/min/L			2.22				
VA	Liters	6.98	(5.8 - 8.1)	6.57	94			



SES Module:	PFT	Referred:	Out-Patients	Scientist: S Wilkinson
Height:	170 cm	Age:	81 Years	Smoking History: Ex-Smoker
Race:	Caucasian	Weight:	68.5 kg	BMI: 24
Indication:	PTX ICC, Lung Ca	Medication:	Spiriva	

		Ref	Pred LL	Pred UL	Pre	%Ref	Post	%Ref	%Chg
Spirometry									
FEV 1	L	2.57	1.77	3.30	1.62	63			
FVC	L	3.45	2.48	4.44	3.68	107			
FEV 1 % FVC	%	75	60	89	44	59			
MFEF 75/25	L/s	1.83	0.68	3.55	0.36	20			
PEF	L/s	7.10	5.11	9.10	4.40	62			
FEV 0.5 / FIV 0.5					1.37				
FeNO (ppb)									
Lung Volumes									
TLC	L	6.50	5.35	7.65	7.87	121			
VC	L	3.45	2.48	4.44	4.01	116			
IC	L	2.61	2.61	2.61	2.27	87			
FRCpleth	L	3.62	2.63	4.60	5.60	155			
RV	L	2.78	2.10	3.45	3.86	139			
RV % TLC	%	46	37	55	49	108			
Diffusing Capacity									
DLCO_SB	ml/(min*mmHg)	22.3	14.4	30.3	8.8	39			
DLCOcSB	ml/(min*mmHg)	22.3	14.4	30.3	9.6	43			
KCO_SB	ml/(min*mmHg*L)	3.8	2.6	5.0	1.5	39			
KCOc_SB	ml/(min*mmHg*L)	3.8	2.6	5.0	1.6	43			
VA_SB	L	6.23	4.86	7.59	5.90	95			
IVC	L	3.45	2.48	4.44	3.38	98			
Hb	g(Hb)/dL				11.80				

Hb measured by Haemoglobinometer



Evidence for contraindications


Wow, look! Nothing!

Evidence

- Anon. Contraindications to use of spirometry. AARC clinical practice guidelines spirometry. 1996 Update. Respir Care 1996; 41:629-36.
- Cooper G. An update on contraindications for lung function testing. Thorax 2011; 66: 714-23.
- Miller et al. General considerations for lung function testing. Eur Respir J 2005; 26: 153-61

Evidence regarding pneumothorax

- Very little
- All CI evidence is largely opinion based 30 years prior to publication
- Little to no research behind recommendations
- Cooper dedicates one small paragraph to discussion around pneumothorax
  - Relative CI only
  - Does make comment that more research is required
- Wait time 3 weeks for further lung collapse

	Complication	Likelihood	Consequence	Risk
Pneumothorax	Lung collapse	3	4	12
	Pain	5	2	10
	Discomfort	5	1	5

Adapted from Cooper BG. Thorax 2011; 66

Case 2

Oh that’s why we do the KCO

Case presentation

- 24F
- Presented to hospital with cough, dyspnea and haemoptysis
  - Small volume
  - Recurrent
  - 5-20c pieces of haemoptysis
- Worsening symptoms for 2 months
- Had attributed to her ‘asthma’

Original Ix

Hb 59

WCC 12

Cr 72

Urea 8.7

Urinalysis

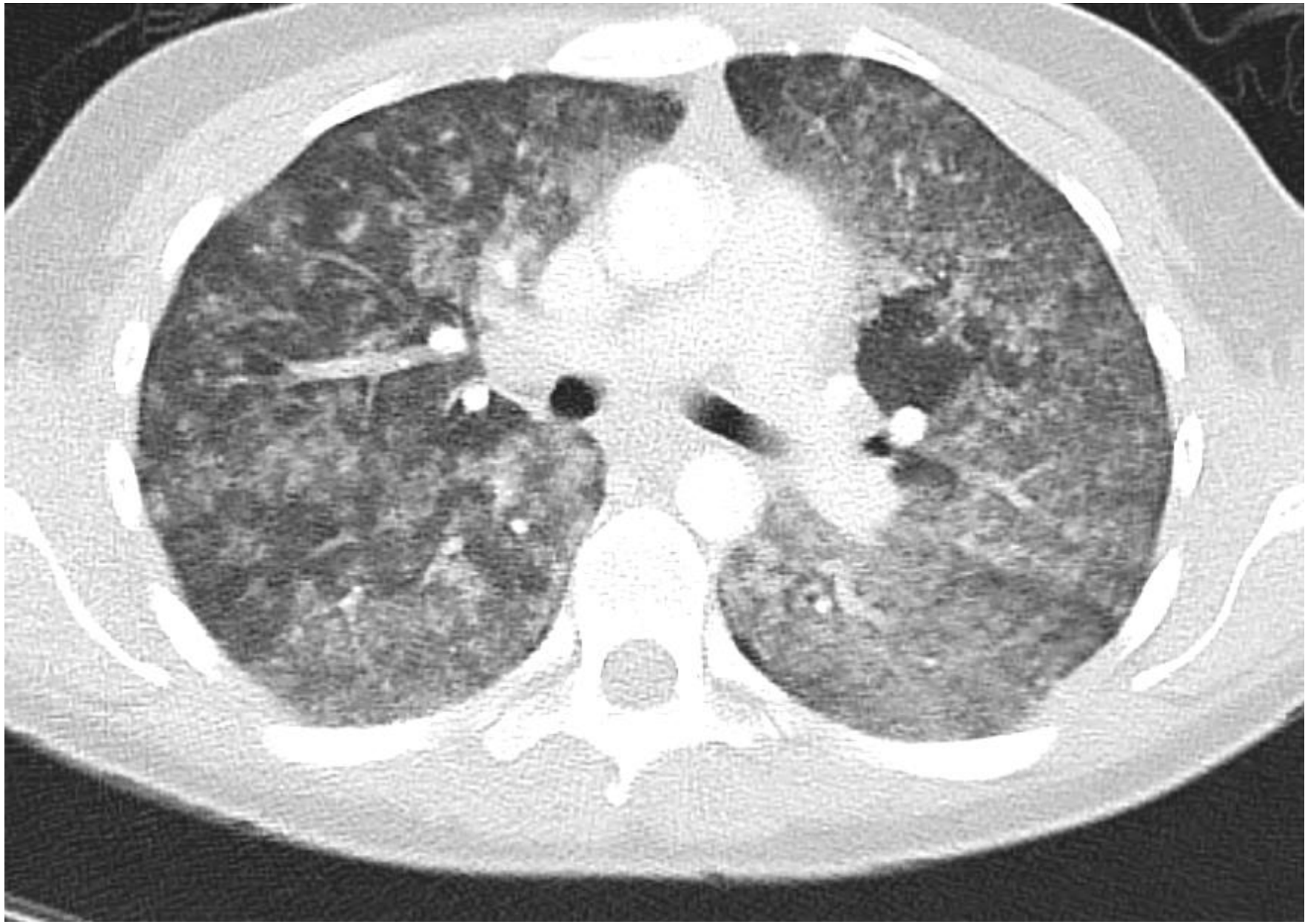
- 2.7g protein
- >500 rbc

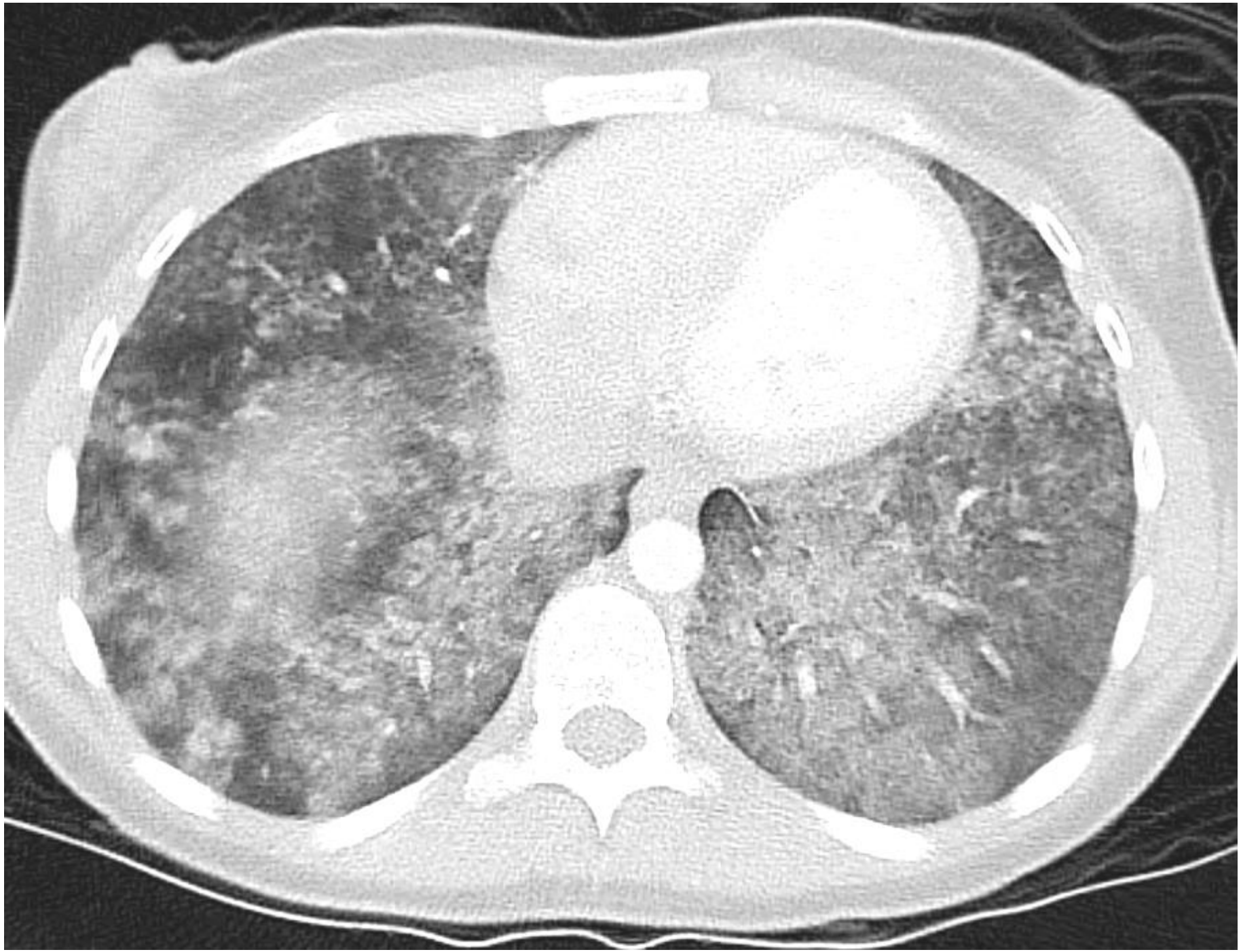
Serology

Serology

- ANCAs – neg
- Anti-GBM – positive at 180U/L (NR < 20)
- ANA – neg
- ENA – neg
- Coags – NR
- BNP

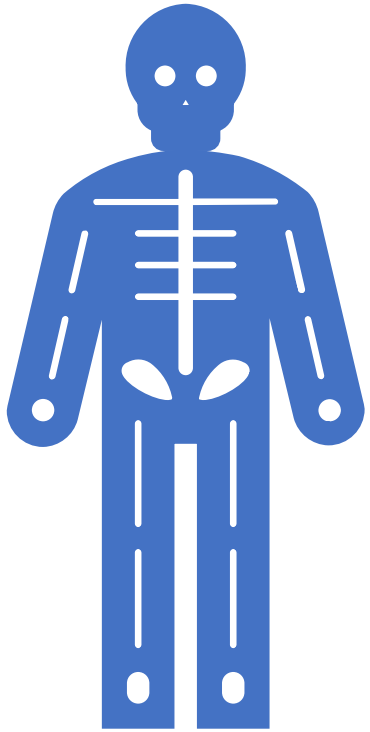
Imaging





Spirometry

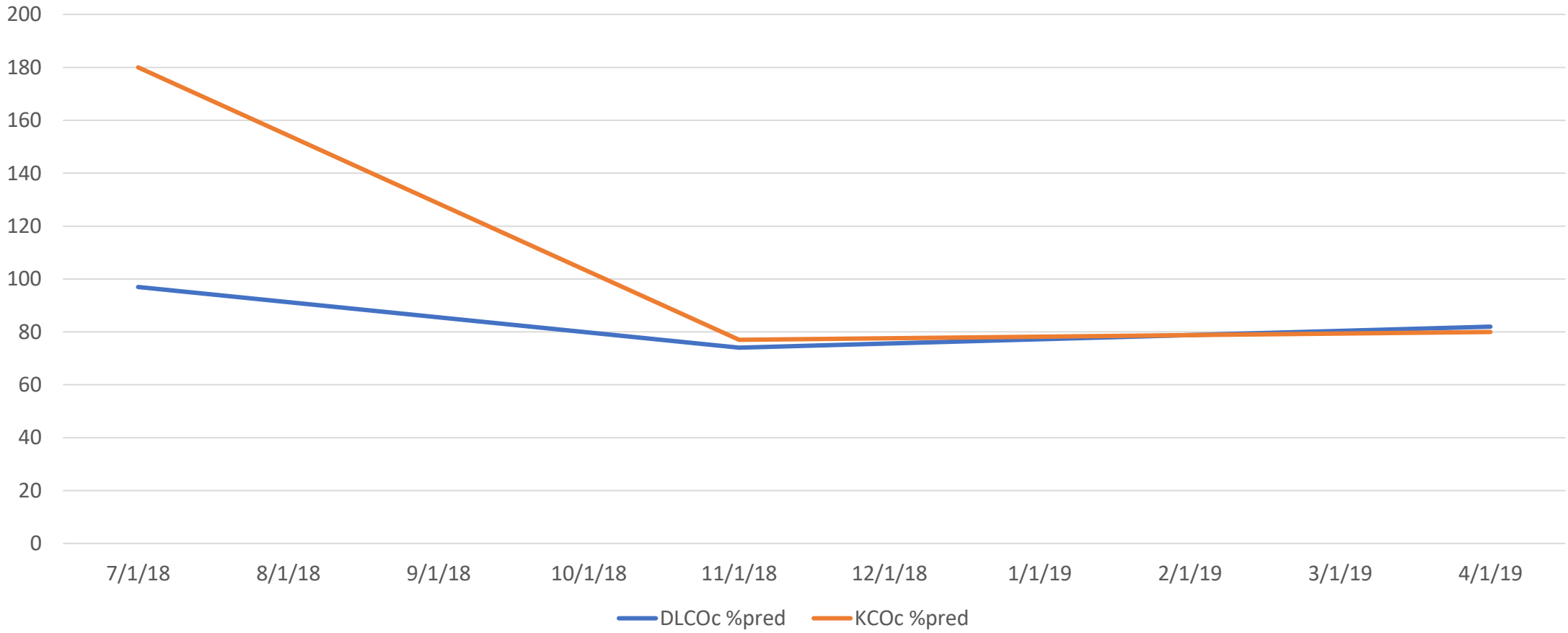
		Ref	Pred LL	Pred UL	Pre	%Ref
Spirometry						
FEV 1	L	3.09	2.49	3.68		
FVC	L	3.52	2.81	4.25		
FEV 1 % FVC	%	88	77	97		
MFEF 75/25	L/s	3.73	2.49	5.13		
PEF	L/s	8.78	5.29	8.26		
FEV 0.5 / FIV 0.5						
IC	L	2.14	2.14	2.14	1.43	67
VC MAX	L	3.52	2.81	4.25	2.09	59
FeNO (ppb)						
Diffusing Capacity						
DLCO_SB	ml/(min*mmHg)	25.2	18.7	31.7	16.1	64
DLCOcSB	ml/(min*mmHg)	25.2	18.7	31.7	24.3	97
KCO_SB	ml/(min*mmHg*L)	5.2	3.9	6.5	6.2	120
KCOc_SB	ml/(min*mmHg*L)	5.2	3.9	6.5	9.3	180
VA_SB	L	4.70	3.60	5.80	2.61	55
IVC	L	3.52	2.81	4.25	1.74	50
Hb	g(Hb)/dL				6.00	
%COHb	%				0.00	



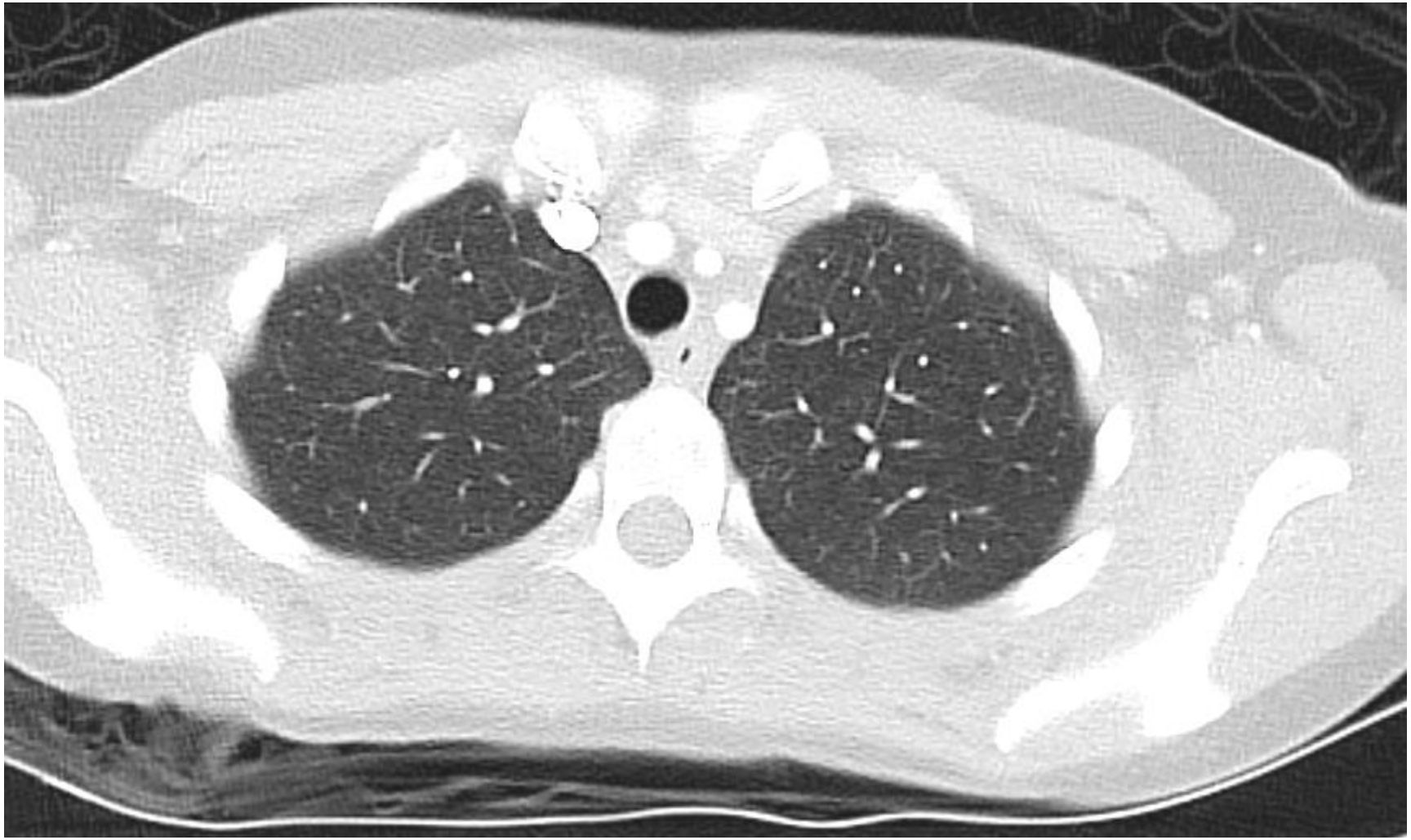
Diagnosis & Treatment

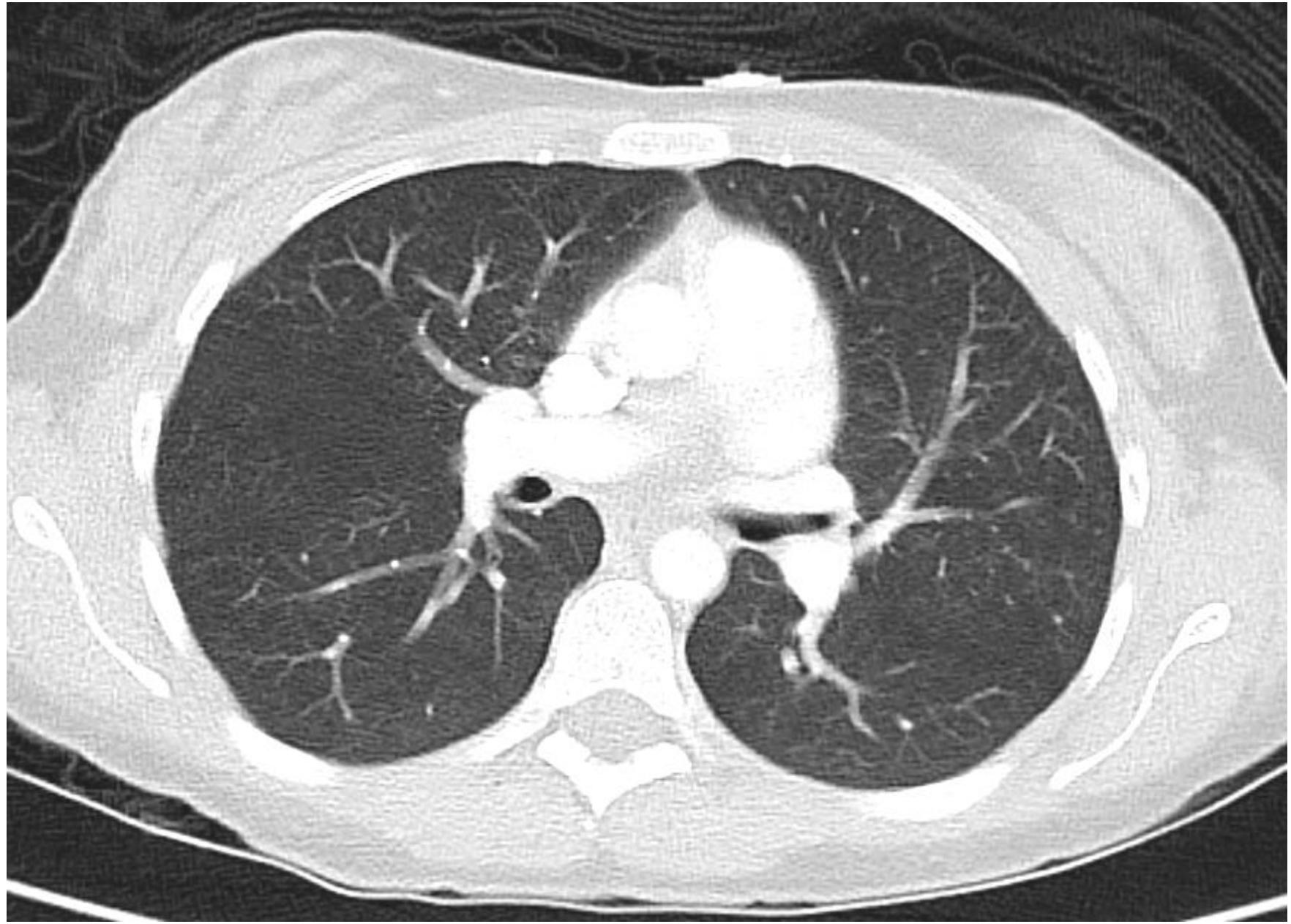
- Renal biopsy = crescents
- Dx of anti-GBM disease (goodpastures)
  - One of the diseases causing diffuse alveolar haemorrhage
- Rx: IVMP + PLEX + CYC
- Continued with PNL + AZA

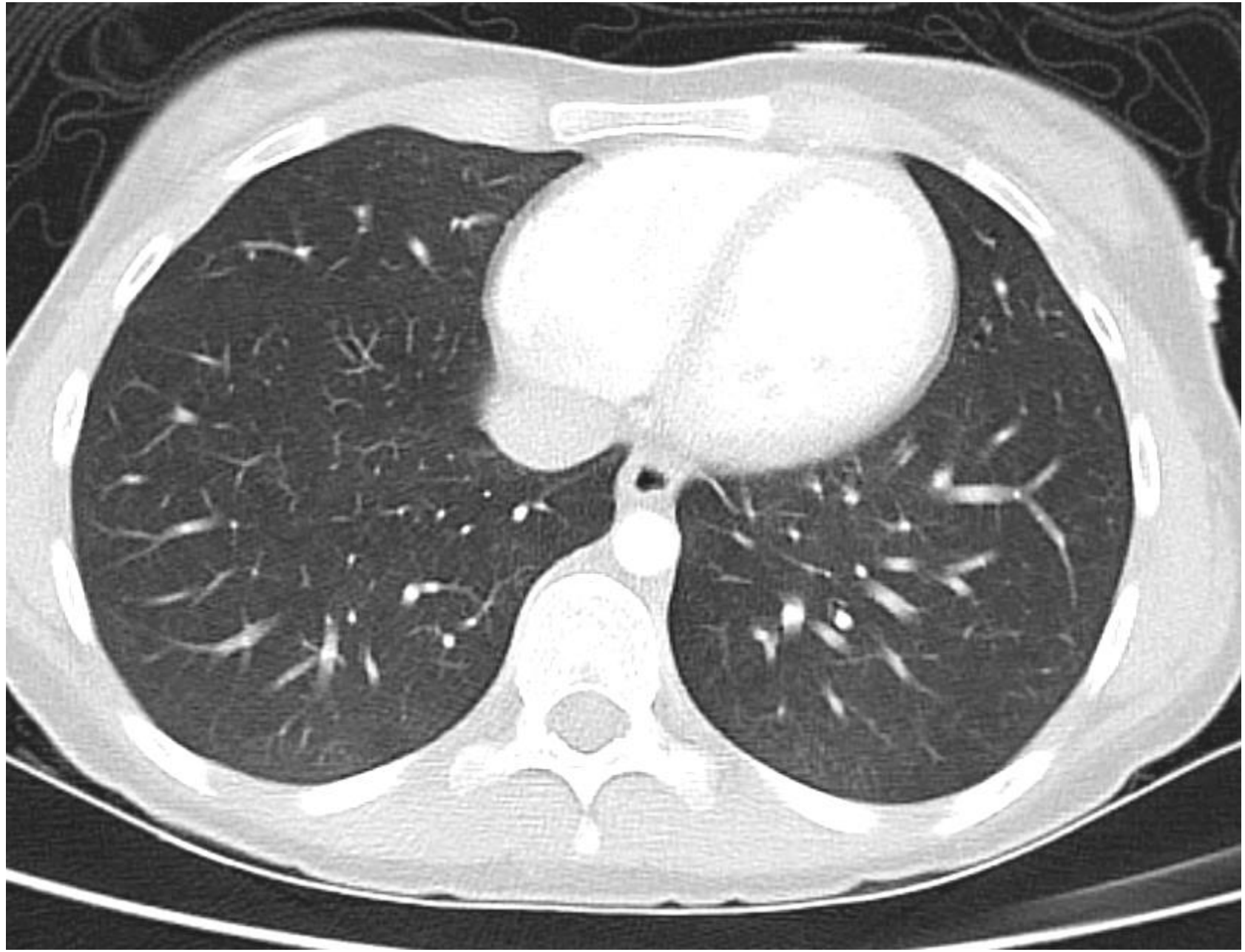
DLCO & KCO over time



Radiology over time

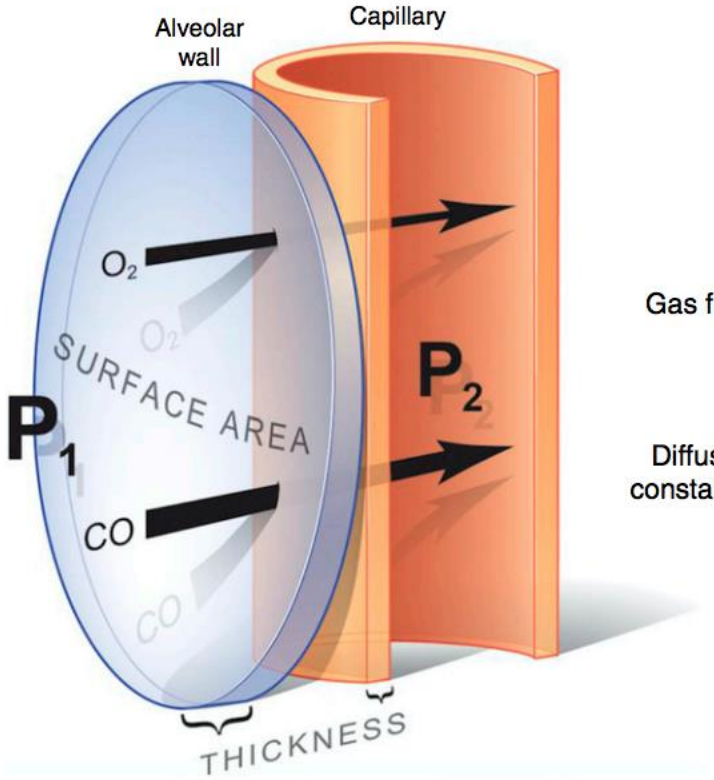






DAH + gas diffusion

- DLCO provides a quantitative measure of effective alveolar-capillary surface area – window to the pulmonary microcirculation
- Diffusion is directly proportional to the surface area and the distance the molecules must travel



$$\text{Gas flow } (\dot{V}gas) \propto \frac{A}{T} \bullet K \bullet (P_1 - P_2)$$

$$\text{Diffusion constant (K)} \propto \frac{\text{Solubility}}{\sqrt{\text{Molecular weight}}}$$

DeCato TW et al. Ann Am Thorac Soc 2016; 13(11): 2087-92

High DLCO

- In our scenario, flooding of alveoli increases the capillary blood volume seen by CO, plus reduced the distance required
- Leads to a disproportionately elevated KCO and DLCO
- Aetiologies of high DLCO
  - Inc Vc
  - Polycythaemia – increased Hb
  - Altitude
  - Muller maneuver
  - Pulmonary haemorrhage
  - Increased CO and pulmonary blood flow - obesity, shunt, asthma, pregnancy, Pagets, wet beriberi, hyperthyoidism

DeCato TW et al. Ann Am Thorac Soc 2016; 13(11): 2087-92

Saydain et al. Chest 2004; 125: 446-52

High KCO in alveolar haemorrhage

- DLCO can be normal, high or even low in pulmonary haemorrhage
- V_A is often normal to low due to discrete loss of alveolar units and lack of alveolar expansion
- Subsequently, Kco is more sensitive than DLCO in detecting pulmonary haemorrhage
- DLCO = Kco / V_A
- One series, peak rise in DLCO was less than 50% above baseline, but the rise in Kco was always > 50%

Hughes JB et al. Am J Respir Crit Care Med 2012; 186(2):132-9

Hughes jB et al. Eur Respir J 2001; 17: 168-74

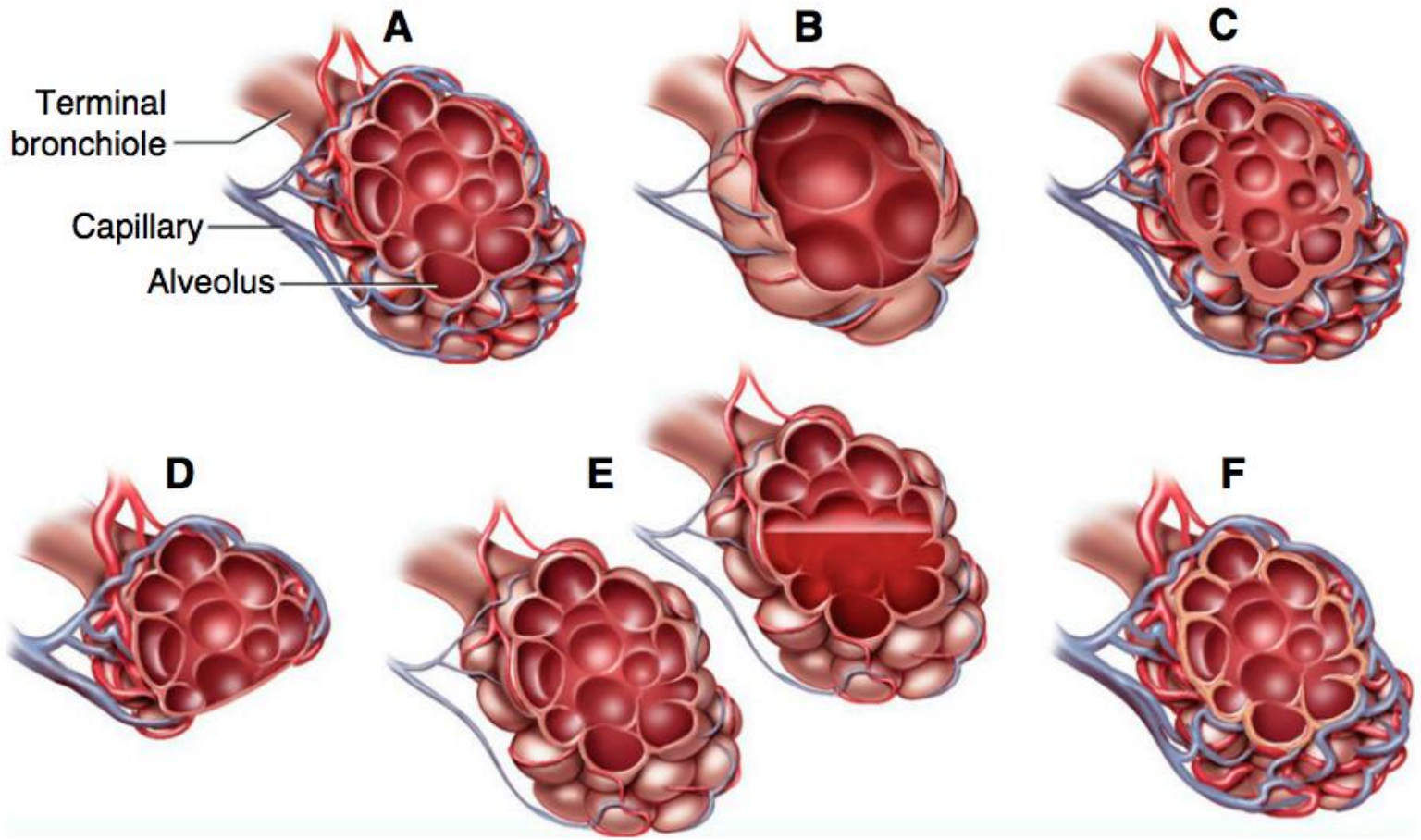
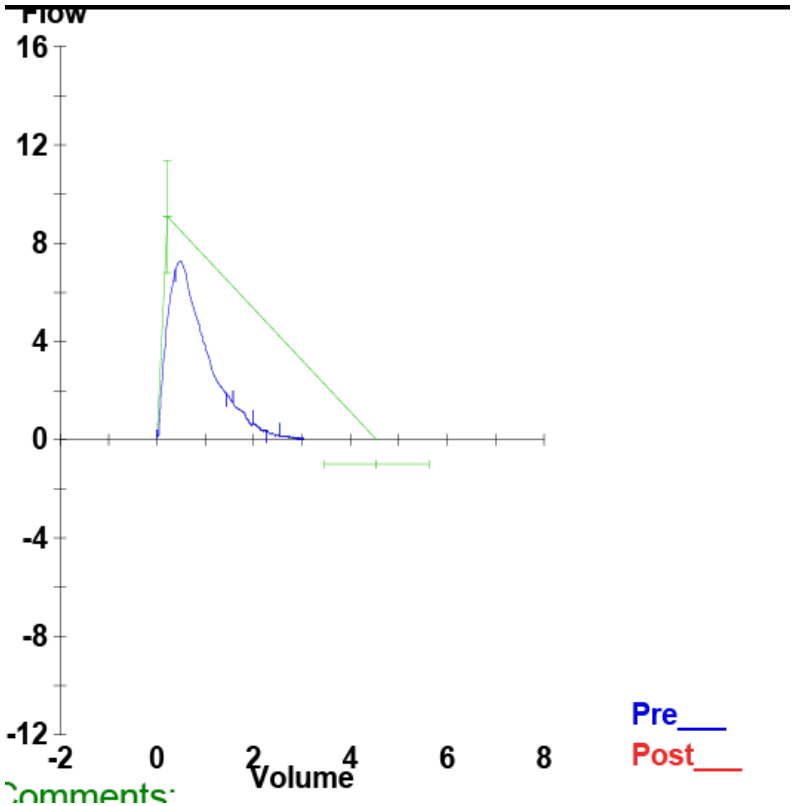


Figure 6. Common diseases that affect the diffusing capacity of carbon monoxide. Most diseases disturb both the membrane component and the capillary blood volume. (*A*) Normal alveolar-capillary interface. (*B*) Emphysema. (*C*) Interstitial lung disease. (*D*) Lung resection. (*E*) Vasculitis. (*F*) Congestive heart failure.

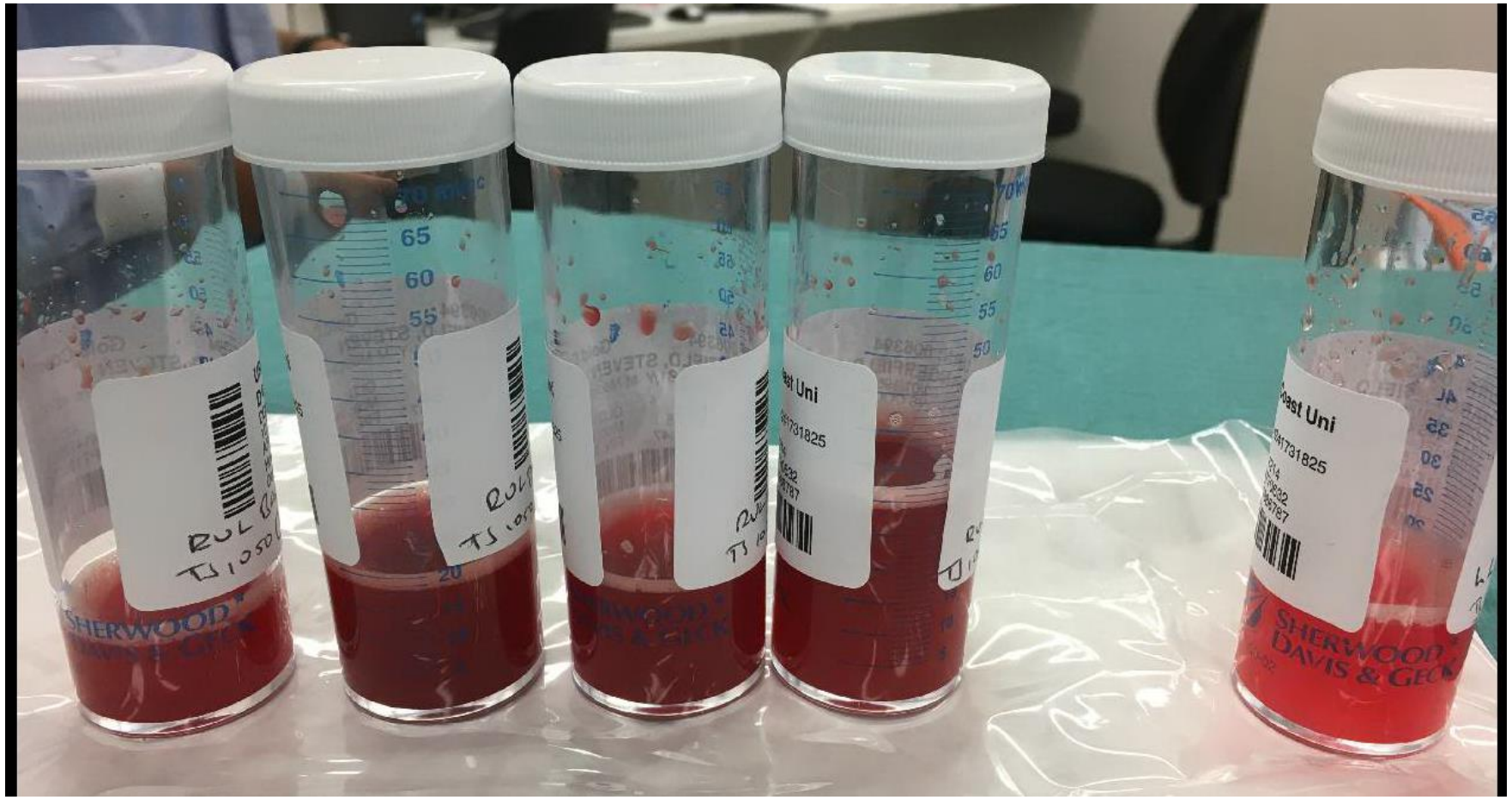
DeCato TW et al. Ann Am Thorac Soc 2016; 13(11): 2087-92

Pulmonary haemorrhage

		Ref	Ref +/- C.I.	Pre Measured	% Ref	P Meas
Spirometry						
FVC	Liters	4.55	(3.5 - 5.6)	(3.04)	(67)	
FEV1	Liters	3.52	(2.6 - 4.4)	(2.04)	(58)	
FEV1/FVC	%	77	(65.2 - 89.5)	67		
FEF25-75%	L/sec	2.91	(1.4 - 4.4)	(1.06)	(36)	
PEF	L/sec	9.08	(6.8 - 11.4)	7.27	80	
Diffusing Capacity (Hb 10.9)						
DLCO	mL/mmHg/min	28.1	(20.1 - 36.1)	33.7	120	
DL Adj	mL/mmHg/min	28.1	(20.1 - 36.1)	(38.4)	(137)	
DLCO/VA	mL/mHg/min/L	4.23	(3.0 - 5.4)	(7.10)	(168)	
DL/VA Adj	mL/mHg/min/L	4.23	(3.0 - 5.4)	(8.09)	(191)	
VA	Liters	6.64	(5.3 - 8.0)	(4.75)	(72)	
IVC	Liters			3.02		



Pulmonary haemorrhage (2)

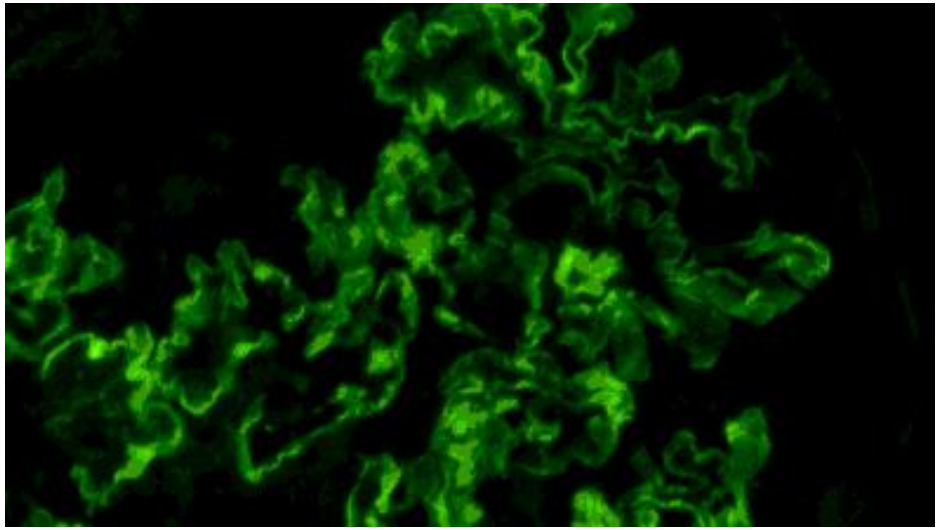


Pulmonary haemorrhage (3)

- Anti-GBM disease
- Pulmonary vasculitis
- SLE
- Idiopathic haemosiderosis
- Other: paraquat, Behcets, cryoglobulinaemia

Anti-GBM

- Incidence 1/million/year
- Two age peaks ➔ 20-30 and 60-70
- Autoantibodies against the basement membrane along alveoli and glomeruli (functional unit of the kidney)
  - Type IV collagen
- Activates complement cascade and subsequent attack and destruction by the body's own white blood cells



Kluth et al. J Am Soc Nephrol. 1999; 10:2446-53

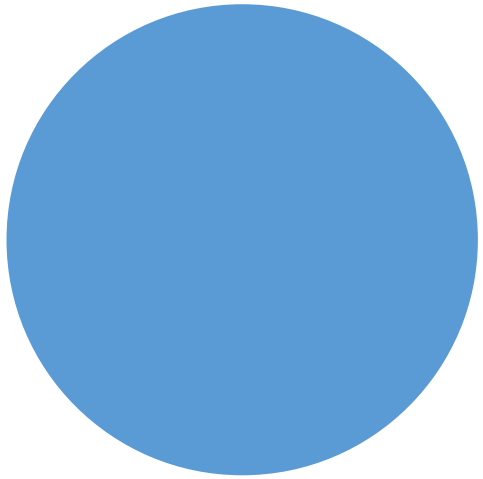
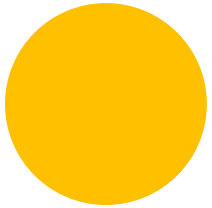
Greco A et al. Autoimmunity Reviews 2015; 14: 246-53

Treatment and prognosis

- Remove the antibody
  - Plasma exchange
- Suppress the inflammation and antibody production
  - IV methylpred and cyclophosphamide
- Maintain remission
  - Steroids and azathioprine
- 80% 5 year survival
- 30% require renal transplant
- Death most likely due to pulmonary haemorrhage

Role of DLCO/KCO in disease management

- KCO used to monitor disease activity and response to treatment in anti-GBM disease
  - Kluth DC et al. Anti-glomerular basement membrane disease. J Am Soc Nephrol 1999: 10; 2444
- All reference article in NEJM 1976
  - Ewan PW et al. Detection of intrapulmonary haemorrhage with carbon monoxide uptake: Application in Goodpastures syndrome. N Eng J Med 1976; 295: 1391
  - Measured kCO along side a CO isotope to detect differences in CO uptake and clearance

The end

Thank you & questions